Measuring Magnetic Fields at Arbitrary Frequencies with an Atomic Magnetometer

K. Netz[a], R. Li[a] and A.N. Luiten[a], C. Perrella[a]

[a]*Institute for Photonics and Advanced Sensing, The University of Adelaide, Adelaide, South Australia 5005, Australia.*

High bandwidth, high sensitivity magnetometry is important for many applications in areas like geological exploration, medical imaging, and fundamental science. Non-linear Magneto-Optical Rotation magnetometers are highly sensitive, and recent developments have shown that they can have bandwidths of a few hundred kHz[1, 2]. One such method uses a phase lock loop to track the Larmor precession frequency associated with the magnetic field strength, reaching a bandwidth of 100 kHz[1]. Another method utilises the Hilbert transform to extract the phase evolution of the Larmor precession to measure AC magnetic fields at frequencies higher than the Larmor precession frequency. This method was shown to reach up to 400 kHz but has a low frequency limit due to the use of a free induction decay measurement scheme[2].

We present a new method to extract the phase evolution of the Larmor precession using novel physics. This is combined with the phase lock loop tracking system to achieve measurement of magnetic fields at arbitrary frequencies. This was shown with measurements of AC magnetic fields between 22 Hz and 1 MHz. This method also maintains the high sensitivity (measured as 260 $\mathrm{fT}/\sqrt{\mathrm{Hz}}$ at 100 Hz) and calibration free benefits of an NMOR magnetometer.

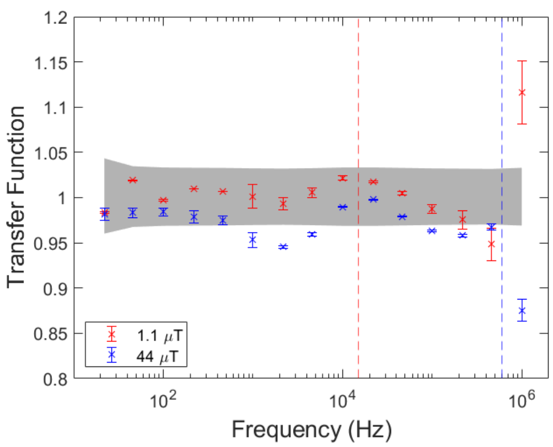

Figure 1: Transfer function measurements of the NMOR method, with measurements from an indpendent single loop induction coil magnetometer used as the reference. The dashed lines show where the Larmor precession frequency is for each bias field. The error bars show the error from the measurements with the NMOR method. The grey area shows the error in the measurements with the independent magnetometer.

[1] R. Li, F. N. Baynes, A. N. Luiten, and C. Perrella, *Physical Review Applied* **14**, 064067 (2020).

[2] N. Wilson, C. Perrella, R. Anderson, A. Luiten, and P. Light, *Physical Review Research* **2**, 013213 (2020).